A Cross-Cultural Comparison of Algebra 1 Students' Achievement

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Abstract

The purpose of this research was to compare American and Albanian students' achievement in Algebra 1. The study compared algebraic solving abilities of 219 students in a city of Albania and 242 ninth-grade American students, residents of an American region. Albanian sample did not use calculators on the test. Of the American sample, 97 students used calculators on the test, whereas 145 did not use them. The three research questions addressed: (1) students' mastering of the overall algebraic achievement, (2) students' mastering of specific domains of algebraic understanding: knowing, applying, and reasoning, and (3) students' preference of algebraic strategies for solving word-problems. The study found that Albanian students outperformed American students on the overall achievement. However, American students who used calculators on the test significantly outperformed not only the American group who did not use calculators on the test, but also the entire Albanian sample. In addition, Albanian students scored significantly higher than their American peers both on 2 out of 3 cognitive domains and on using algebraic strategies.

Introduction Various studies have focused on cross-cultural comparisons in the field of school mathematics. This study was designed to make a contribution to this field by comparing Algebra achievement of ninth grade students in the U.S. and Albania. The topic of this study was Algebra 1 because this mathematics course is required in every high school curriculum of every culture or country that has education as a priority.

Achievement and its Assessment

The object of this study is conducive to mathematics achievement of 9th graders. According to Ruiz-Primo (1998), mathematics achievement may be conceived as students' abilities in two component domains: *understanding domain* and *strategic domain. Understanding domain* consists of acquisition of algebraic facts, procedures and concepts, whereas strategic domain has to do with the abilities how to present word-problem solutions.

Assessment of "Understanding Domain"

For assessing students' understanding, this study adopted the framework used by the Third International Mathematics and Science Study (TIMSS), in which experts divided the *understanding domain* into three specific domains: *knowing, applying, and reasoning* (Mullis, 2004). *Knowing* refers to recalling definitions and properties, recognizing/identifying algebraic relations and functions, and computing the values of algebraic expressions. *Applying* deals with formulating algebraic situations, modeling problems, selecting appropriate algorithms to solve routine problems, and interpreting given algebraic models. *Reasoning* deals with conjecting, analyzing, generalizing, justifying, and solving non-routine problems.

Assessment of "Strategy Domain"

The strategic domain can be assessed by examining mathematical models used by students, as they attempt to solve word problems. Students can communicate their explanations for a mathematical strategy or solution in a variety of models: numerically, verbally, diagrammatically, graphically, by tables of data or symbolically (with algebraic symbols or equations) (Shield & Galbraith, 1998).

Research Questions

The following research questions were based on the need for comparing students' overall achievement, achievement in specific domains of understanding and achievement in the strategic domain:

1. Is the difference between the mean scores in the overall algebra achievement of students in the U.S. and Albania significant?
2. Are the differences between the mean scores in each specific domain of algebra understanding significant?
3. Does the variable of "country" significantly predict the students' preference of algebraic strategies when addressing the algebra word problems?

Literature Review

In the absence of research involving a direct comparison between the U.S. and Albania, this study focused on other available studies, no matter whether they were domestic, international or multinational. More

specific information about the overall achievement of the U.S. students in algebra is obtained from the Trends in International Mathematics and Science Study (TIMSS), designed to measure students' literacy that is dependent on school curriculum. The first TIMSS was conducted in 1995. It shows that, out of 41 participating countries, the U.S. eighth graders were outperformed in mathematics by eighth graders of 27 countries (Beaton et al., 1996). The second TIMSS Study (TIMSS 1999) shows that U.S. eighth graders performed below the international average, even though they improved their mathematics results of the first TIMSS Study. TIMSS 2003, using stratified random samples representative of each country's population, assessed 8,912 eighth graders in 232 schools. In the content of algebra, the U.S. students performed above the international average. They outperformed their peers in 25 countries, on average, and were outperformed by students in 9 countries (NCES, 2005).

TIMSS also used a three-type cognitive skill categorization of items: knowing facts and procedures, using facts and concepts to solve routine problems, and mathematical reasoning. TIMSS 1999 found that students in the industrialized countries that were not grouped into the highest achieving cluster tend to show weaker scores in items that require reasoning skills. These industrialized countries include Canada, Australia, England, and the United States (Mullis et al., 2000). TIMSS 2003 study showed that in knowing domain, the U.S. performed above the international average, outperforming 30 countries. In this cognitive domain American students were outperformed by 14 countries, including 7 European countries. In applying domain, the U.S. outperformed 28 countries and were outperformed by 16 countries.

The only reliable information regarding Albania achievement in multinational studies is related to Albania participation in PISA 2000, where students of this country scored second worst in mathematics (OECD, 2001). The Institute of Pedagogical Studies in Albania recently conducted two studies to examine, among other things, students' work with algebra word problems given on the National Leaving Examinations. The findings showed that the vast majority of students preferred a numerical mode of representation, 37% of answers were in verbal and diagram mode, and only 11% were represented in an algebraic mode (Lulja, 2003).

Methodology and Instruments

The sample of American students was chosen from Grand Forks county, state of North Dakota. Four schools were selected in consultation with local education authorities to represent the full range of the county's high schools. The total number of students included in the Grand Forks sample was 242. The American sample consisted of two groups. The first group included 7 classrooms, where students did not use calculators during the test and 5 classrooms, where students were allowed to use calculators.

The sample of Albanian students was chosen from Durres region. This sample included one outstanding school in the city, two average schools in rural areas, and one school in the countryside. Of the four chosen schools, three were comprehensive and one was vocational. The sample consisted of all Algebra 1 students present on the first and second hour period on the day each of the four schools were visited and included 226 students.

A Texas publicly-released standardized test was administered to all Algebra 1 students. A combination of 9 multiple-choice items and 5 free-response items was used to assess students' overall achievement, achievement in each understanding domain (knowing, applying, and reasoning) and the achievement in the strategic domain of Algebra 1. Multiple-items required students to circle a letter to indicate one choice among five alternatives, each of which might be a number, a word, or a phrase. Free-response items required students to construct their own responses. Four items (1, 2, 5, and 7) of the test were classified to match the knowing domain (see table 2). Six items (8, 9, 13, and 14) were qualified to assess the applying domain. Four items (6, 10, 11, and 12) were classified. Initially, the 14 items of the test were scored dichotomously. The "correct" or "wrong" results were used to measure both students' overall achievement and achievement in each understanding domain. Then 3 of the 14 items (items 10, 11, and 12), consisting of word-problems, were used to measure students' strategic domain. The answers on these items were considered for the second time, whether they were algebraic or not algebraic, regardless of being correct or wrong.

Results, Findings and Conclusions

Research Question 1

The research question is addressed by taking into account that some of the U.S. students used calculators on the test and some did not. The descriptive statistics of American calculator users, American calculator nonusers, and Albanian students (who did not use calculators on the test) are given in Table 1.

Table 1. Mean Scores on the Overall Test by the U.S. and Albanian Students.

	US students			AL students		
	n	M	SD	n	M	SD
Calc. users	97	7.70	2.450	-	-	-
Calc. Nonusers	145	5.63	2.674	220	6.97	2.964
Entire sample	242	6.46	2.775	220	6.97	2.964

The results of t-test procedures show that the difference between the mean scores of: (1) American calculator users and nonusers is significant, (2) American calculator users and Albanian students is significant, (3) American calculator nonusers and Albanian students is significant, (4) American students and Albanian students is not significant. Table 2 shows the percentages of students in each country, who were able to answer each item of the Achievement Test successfully.

Table 2. Percentages of U.S. and Albanian Students who Were Successful on the Overall Test by Item.

	US	AL
Item Number	n = 242	n = 219
1. Computing the value of an algebraic expression	66.1%	80.1%
2. Identifying a quadratic function	64.9%	87.2%
3. Interpret the solutions of a quadratic equation	39.3%	46.5%
4. Solving a linear equation	59.5%	64.6%
5. Recognizing the graph of a linear function	63.6%	76.5%
6. Finding the equation that represents the rate of reading	45.0%	38.1%
7. Recalling the properties of a parabola	55.0%	74.3%
8. Using the concept of slope	48.8%	53.1%
9. Finding the algebraic expression of a given situation	43.0%	46.6%
10. Finding the lengths of three wire pieces	63.2%	46.6%
11 .Finding the number of boys and girls in a classroom	22.7%	19%
12. Finding the number of saving-months to buy a fridge	58.3%	38.1%
13. Finding the graphical interpretation of an inequality	14.9%	16.4%
14. Solving a linear inequality with absolute value	1.7%	7.1%

Research Question 2

Table 3 contains the descriptive statistics that characterize the specific domains of understanding. A two-way MANOVA was conducted to determine the effect of country and calculator on the three dependent variables of knowing, applying, and reasoning. MANOVA results indicate that (1) "knowing" significantly differs for "country", (2) "applying" significantly differs for "country", and (3) "reasoning" significantly differs for "country" [F (1, 465) = .5.599, p=.018] and for "calculator use". Another analysis, conducted separately for the U.S. sample, was intended to examine the effect of calculator use. The results of t-tests showed that the differences between the mean scores of the U.S. calculator users and nonusers were significant at the .001 level for the the three variables.

Table 3. Mean Scores on the Specific Domains of the Achievement Test by the U.S. and Albanian Students.

	Knowing			Applying			Reasoning		
Calculator	n	M	SD	n	M	SD	n	M	SD
Albania									
Yes	-	-	-	-	-	-	-	-	-
No	225	3.18	1.01	221	2.37	1.48	220	1.42	1.278
US									
Yes	97	3.07	1.01	97	2.49	1.17	97	2.13	1.222
No	145	2.11	1.21	145	1.79	1.28	145	1.73	1.180
Entire Sample	242	2.50	1.23	242	2.07	1.28	242	1.89	1.211

Research Question 3

Table 4 represents the percents of American students (either calculator users or nonusers) and Albanian students who gave algebraic solutions to each of the three word problems of the test. The last row of the

table indicates the percentage of students that managed to solve algebraically at least one out of the three problems.

Table 4. Percents of Students who Used Algebraic Methods.

Item	Albania	US	U.S.	
			Calc. users	Nonusers
	n=219	n=242	n=97	n=145
10	31.9%	3.7%	7.2%	1.4%
11	29.2%	8.3%	13.4%	4.8%
12	19.5%	23.1%	33.0%	16.6%
At least one item	44.2%	26.0%	38.1%	17.9%

Results of the regression analysis show that the two countries significantly differ with respect to using algebra in items 10 and 11.

Conclusions

This result shows that students of both countries have difficulties with learning algebra. Below are presented the conclusive remarks about the main differences that correspond to the research questions of this study: (1) on average, Albanian students outperformed American students. However, Albanian students were outperformed by the American group that used calculators on the test; (2) compared with American students, Albanian students scored higher on 2 out of 3 cognitive domains, namely, on the cognitive domains of “knowing” and “applying” and scored lower on the cognitive domain of “reasoning”. However, the group of American students who used calculators on the test scored higher than the Albanian group of students in the cognitive domains of “applying” and “reasoning”, but not on the cognitive domain of “knowing”; (3) Albanian students were more inclined than their American peers to use algebra for solving relational algebra word problems. This conclusion holds for the three American groups, namely, the calculator users, the nonusers, and the mixed group.

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